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FLUORESCENT MATERIALS INDEX SOIL MOVEMENTS

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ABSTRACT

Tracing movement and dispersion of soil-sized fluorescent particles is a promising method for detecting and describing soil erosion. Actively eroding and stable sites are readily identified; size of particles in motion and causal agents may also be inferred. Equipment is simple to operate, and no health hazards are involved.

There is a need for easy-to-use methods of recognizing or identifying active erosion, determining its cause, and appraising relative erosion rates in mountain watersheds. Such information should be available for use in prescribing and evaluating corrective treatments for actively eroding areas or selecting management options on potentially erodible areas. Furthermore, decisions as to whether or not erosion is taking place at an accelerated rate require methods that can be applied to adjacent disturbed and undisturbed areas for comparison.

Because of the variability in both soils and local climate, erosion appears differently at different places. Evidence such as muddy streams, mudflows, dry gravel cones, topographic slumping, or other mass soil movements are clearly recognizable effects of erosion; and several qualitative indicators are commonly used to detect erosion occurrence. These include study of visible factors on the ground

surface as well as study of streambed characteristics (Gleason 1953). Certain physical measurements to quantify sediment loss from hydrologic units include use of gully transects and other aids to estimate soil loss per unit area (Gleason 1957), measurement of bedload sediment volume deposited at a settling point or debris basin (Leaf 1966), and determination of weight of suspended sediment per unit volume of streamflow (Inter-Agency Committee on Water Resources 1963). These methods are useful in determining volumes of materials transported from a land unit, but they provide no insight as to sediment sources. Nor do they indicate patterns of soil movement on eroding surfaces.

Recognition of less obvious or insidious detachment and transport of smaller particles requires closer and more careful observation. Interpreting this degree of soil movement generally requires some identification of the soil material for repeated reference. Advances in detection of tagged materials using short-lived radionuclides have provided a sensitive method for detection of soil particle movement (Wooldridge 1965). However, the ability to detect radionuclides attached to soil materials is reduced with time due to onsite dispersion and radioactive decay. Equipment requirements, radioactive hazards, and reproducibility are particular disadvantages.

Fluorometric particle identification also provides a means of following materials in transit. In general, this entails the introduction of detectable artificial particles into a natural environment. The introduced material is chosen to closely resemble and reproduce the transport characteristics of natural particles. Detection of fluorescent compounds can approach or exceed that of radioactive materials in sensitivity, and the method has been successfully applied to studies of atmospheric diffusion of aerosols (Stanford University 1955). Fluorescent-coated natural particles have also been used to analyze sediment transport along rivers and beaches (Yasso 1962). More recently, Young and Holt (1968) reported use of a specially prepared fluorescent glass to trace soil movement on cultivated experimental plots.

In this preliminary study, natural ore (sp. gr. 3.83) containing fluorescent willemite (zinc silicate with a manganese activator) was used as a tracer. This material has a spectacular yellowish-green response to ultraviolet light (2,500 Angstrom units) emitted by inexpensive mineral-prospecting lamps commonly in use. Prior to application, the willemite ore was crushed and graded to sizes equivalent to soil fractions.

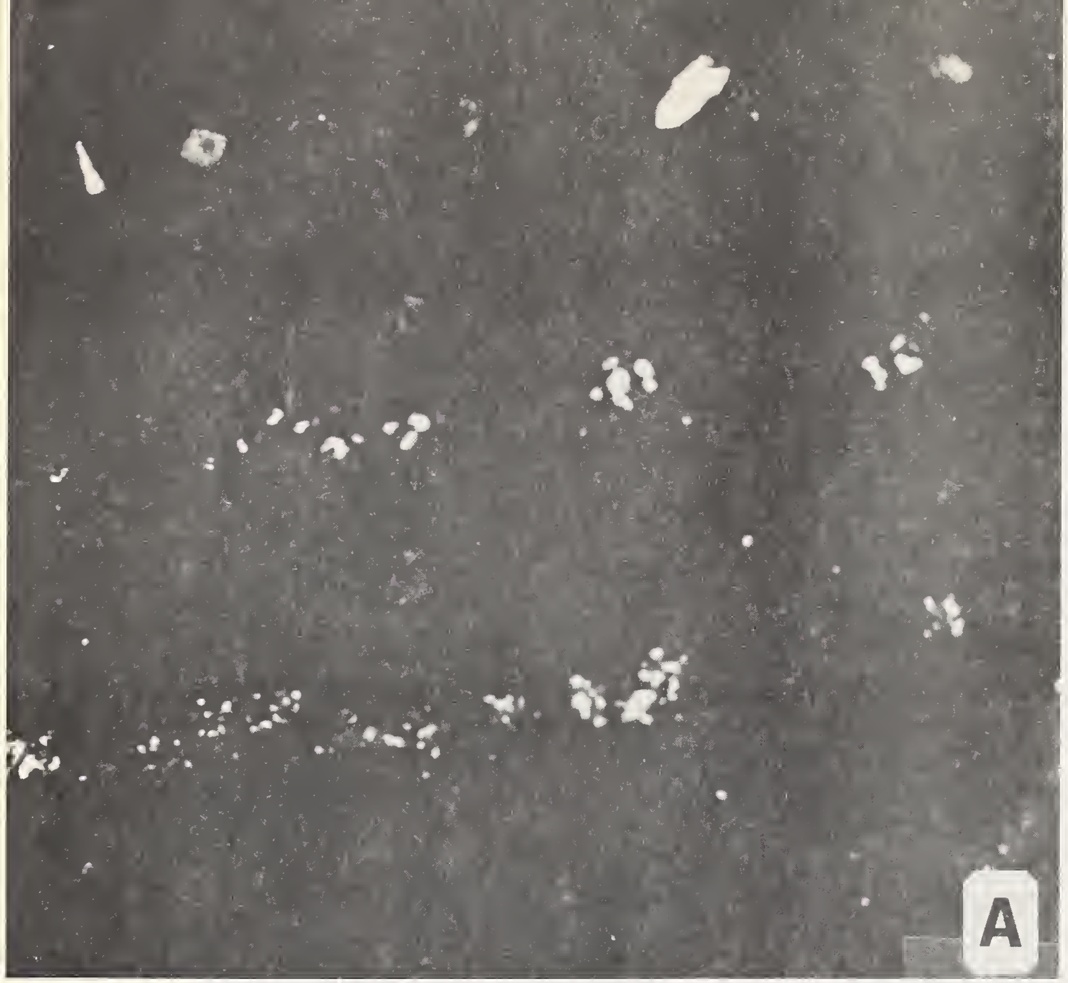
Six plots representing a range of erosion activity from high on bare sites to expected stability in a timber type with herbaceous understory were selected for study. Soils on all plots were gravelly loams derived from basalt, with easterly exposures on 12- to 15-percent slopes. In October 1967, referenced bands of sand- (0.2-2.0 mm.),

gravel- (2.0-5.0 mm.), and stone-sized fluorescent particles were established on the soil surface of each plot. Patterns established on three plots are illustrated by figures 1A, 2A, and 3A.[1/]

Reexamination of the plots in September 1968 showed that evidence and relative rates of erosion can be detected by this method (figs. 1B, 2B, and 3B). As anticipated, the smallest sized material was the most sensitive indicator of erosion activity. During the period of study, this material was displaced a maximum of 6 inches from the reference band on the stable plot (fig. 1), 5 feet under the median condition represented by figure 2, and as far as 15 feet on the most actively eroding plot (fig. 3). Movement and burial of the larger sized particles was also apparent on the actively eroding plots, in contrast to their incorporation into litter accumulating on the stable plot.

No estimate of the relative importance of agents responsible for particle transport was possible in this study. Wind and water erosion moved material in the same general direction at these plot locations. However, some uphill movement of the smaller particles can be seen in figure 2B. We feel that surface water released by snowmelt when protective cover was dormant was the major cause of movement. By periodically reexamining sites at more frequent intervals than the 1-year period in this study, one could trace the progress of total particle movement through different seasons. From this information, inference as to the relative contributions of different erosion-causing forces would be possible.

[1/] Photographs are used as aids in describing the method but are not normally required for field analysis.



A, Bands of fluorescing minerals established in October 1967 on stable plot.

B, Same plot in September 1968. Approximate location and distance between larger particles maintained during enlargement.

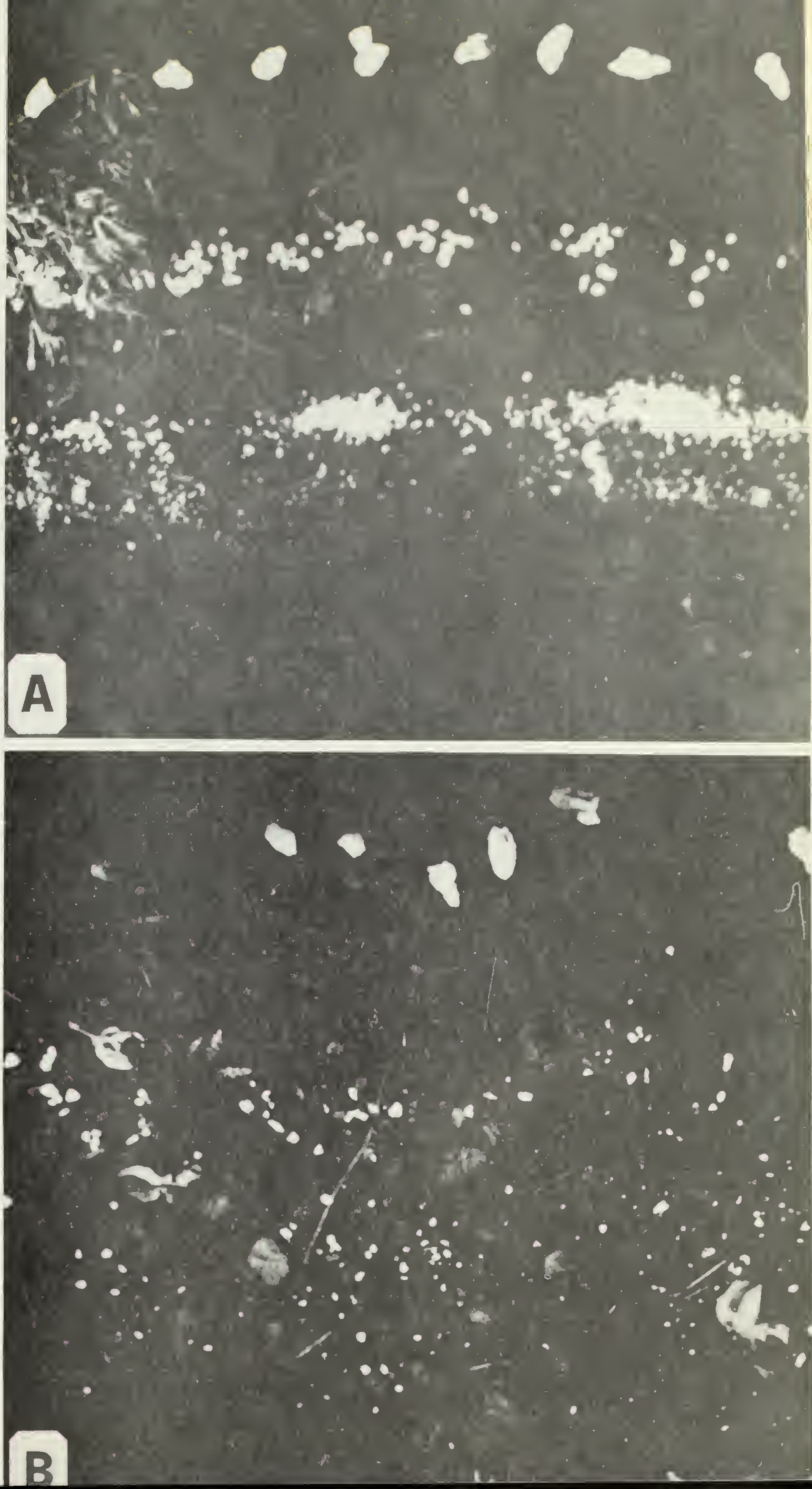


Figure 2.--

A, October 1967. Similar bands on plot of median stability.

B, September 1968. Location of bands on median condition plot.

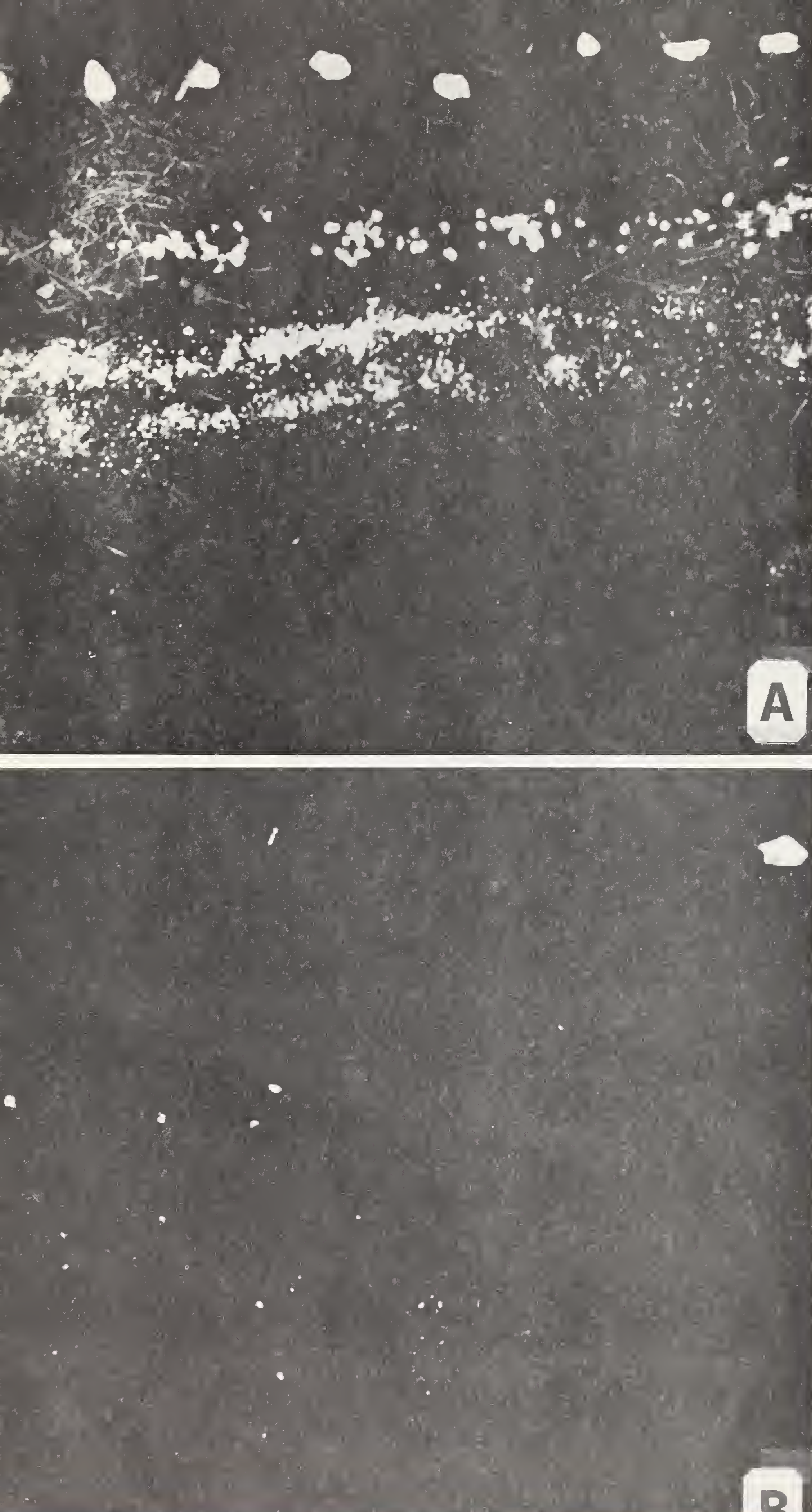


Figure 3.--

A, Bands of minerals on plot of suspected high erosion rates, October 1967.

B, Remaining isolated minera particles on this most activ plot, September 1968.

LITERATURE CITED

Gleason, Clark H.
1953. Indicators of erosion on watershed land in California. Amer. Geophys. Union Trans. 34: 419-426.

Gleason, Clark H.
1957. Reconnaissance methods of measuring erosion. J. Soil & Water Conserv. 12: 105-107.

Inter-Agency Committee on Water Resources.
1963. Measurement and analysis of sediment loads in streams. Subcomm. Sedimentation, Rep. 14, 151 pp., illus.

Leaf, Charles F.
1966. Sediment yields from high mountain watersheds, central Colorado. Rocky Mountain Forest & Range Exp. Sta. U.S.D.A. Forest Serv. Res. Pap. RM-23, 15 pp., illus.

Stanford University.
1955. The Stanford fluorescent-particle tracer technique. Dep. Chem. Reproduced by the Armed Services Tech. Inform. Agency, Rep. AD 91194, 153 pp., illus.

Wooldridge, David D.
1965. Tracing soil particle movement with Fe-59. Soil Sci. Soc. Amer. Proc. 29: 469-472.

Yasso, Warren E.
1962. Fluorescent coatings on coarse sediments: an integrated system. Office Naval Res., Geogr. Br., Tech. Rep. 1, 48 pp., illus.

Young, R. A., and Holt, R. F.
1968. Tracing soil movement with fluorescent glass particles. Soil Sci. Soc. Amer. Proc. 32: 600-602.